1.2 Krill variability, krill fishing, & important physical processes

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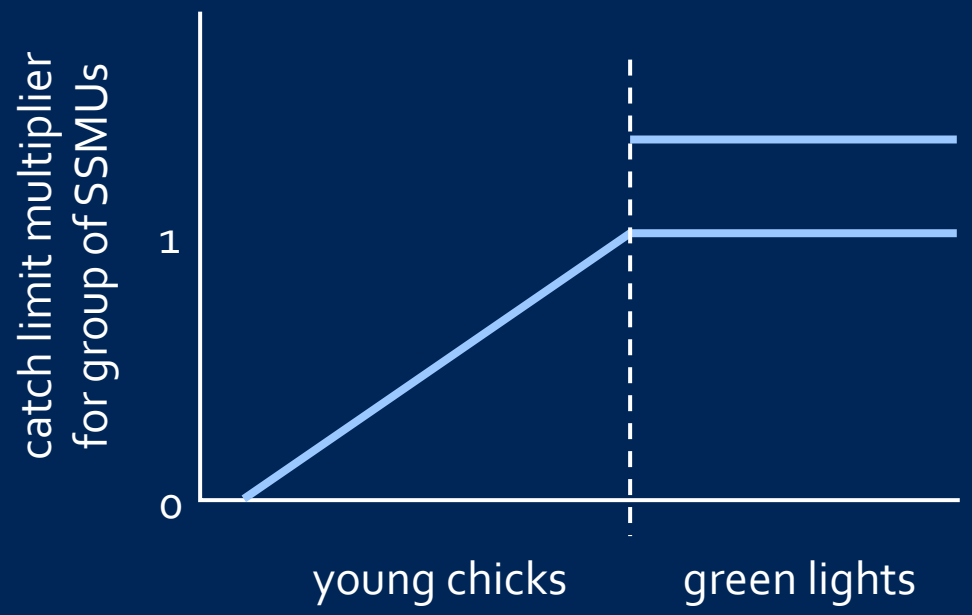
Southwest Fisheries Science Center
Antarctic Ecosystem Research Division

TOR QUESTIONS: 4, 5



1.6 Synthesis

1.5 Adjust up

1.4 Base catch limit

1.6 Adjust down

1.2 & 1.3 Background

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Overview

Three major arguments are made about the role of the physical environment and the ecology of krill that impact the ability of FBM to progress at CCAMLR.

1) Sea ice variability - sea ice impacts the availability of krill to predators and the fishery

2) Advection and retention – krill are often assumed to be passive particles that are advected through the system, and some argue there is always an upstream supply (flux)

3) Seasonality – following 1 and 2, krill availability may be impacted by seasonal sea ice expansion and retreat and directed seasonal migration

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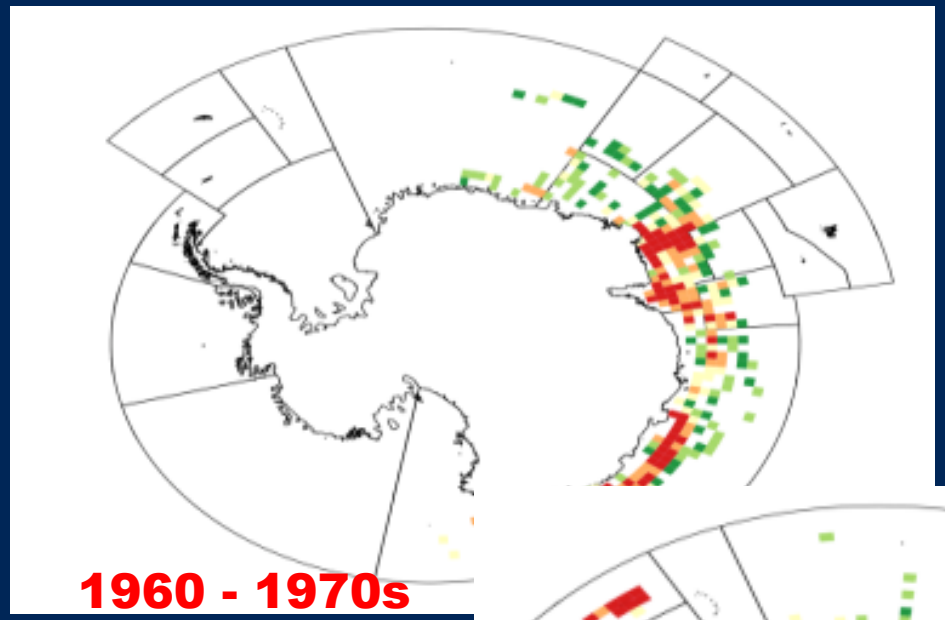
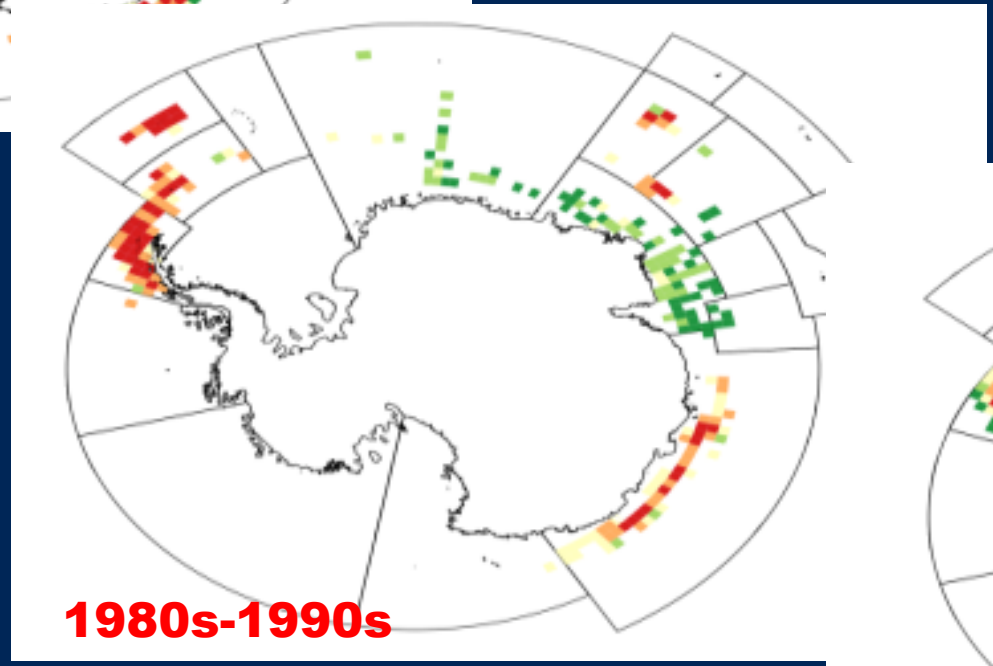
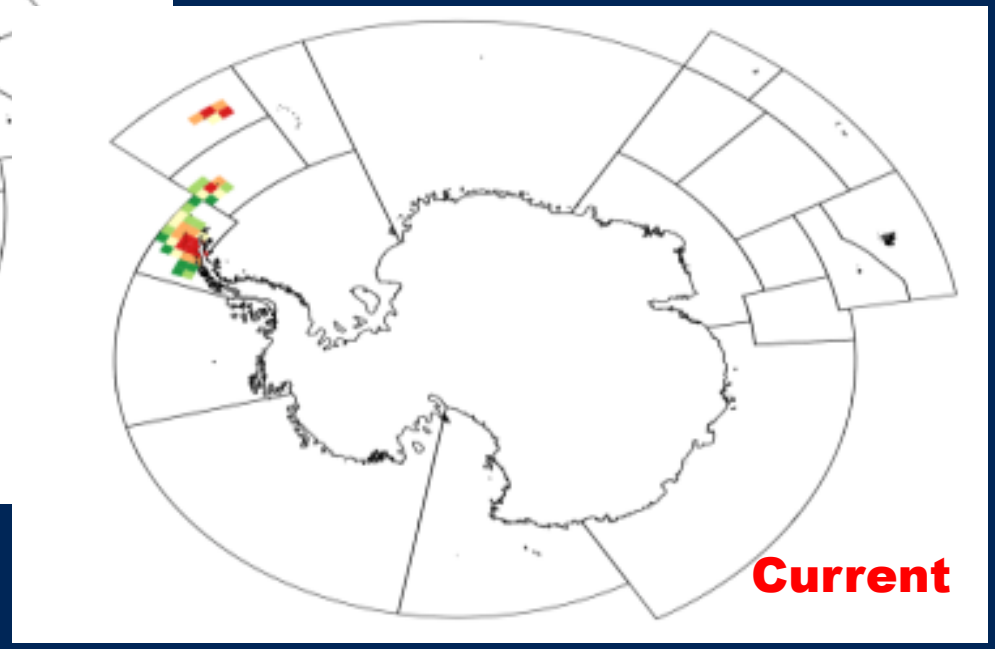
Over time the fishery has concentrated its effort more quickly than managers have subdivided catch







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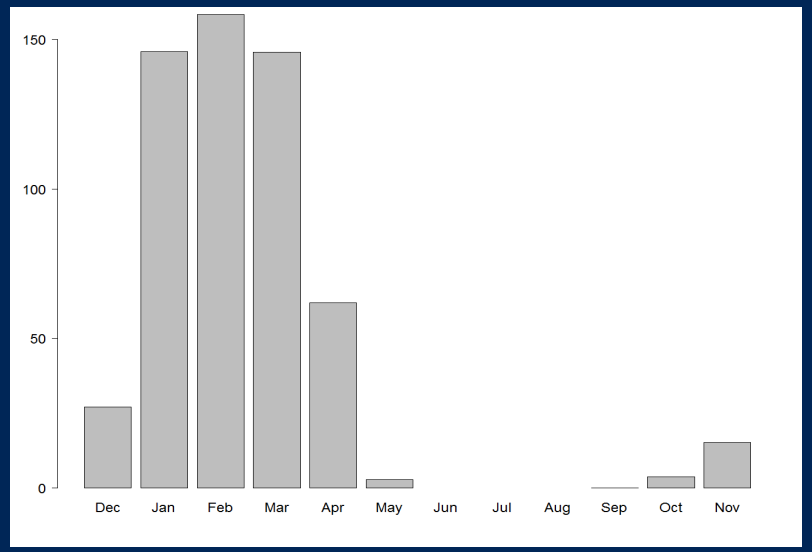
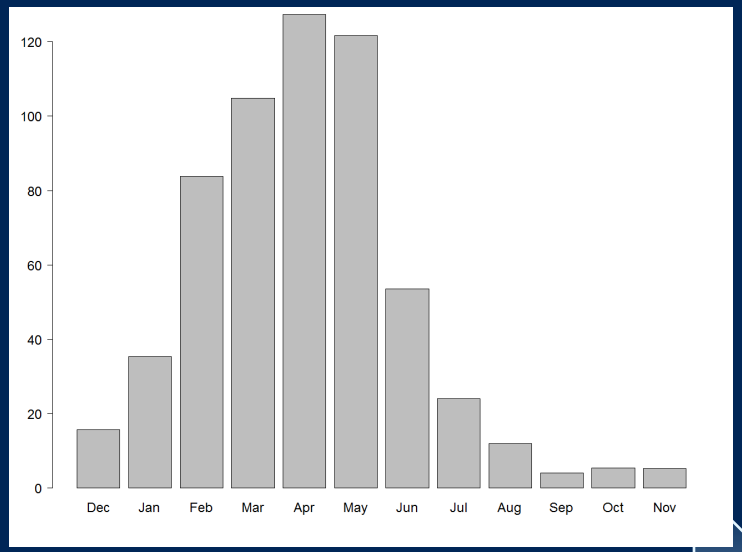
Timing of fishery has changed and requires data outside normal monitoring period

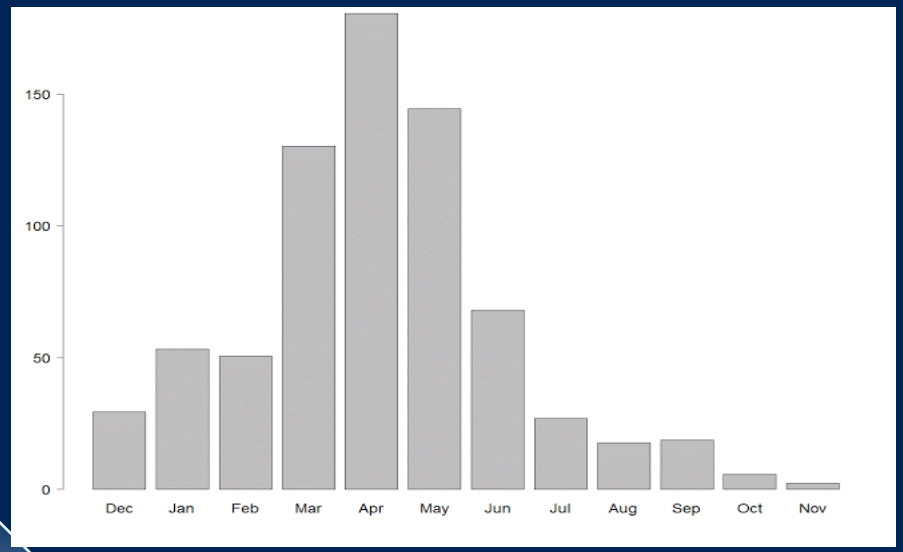
1980-1993



1994-2008



2009-2015



Fishery shifting

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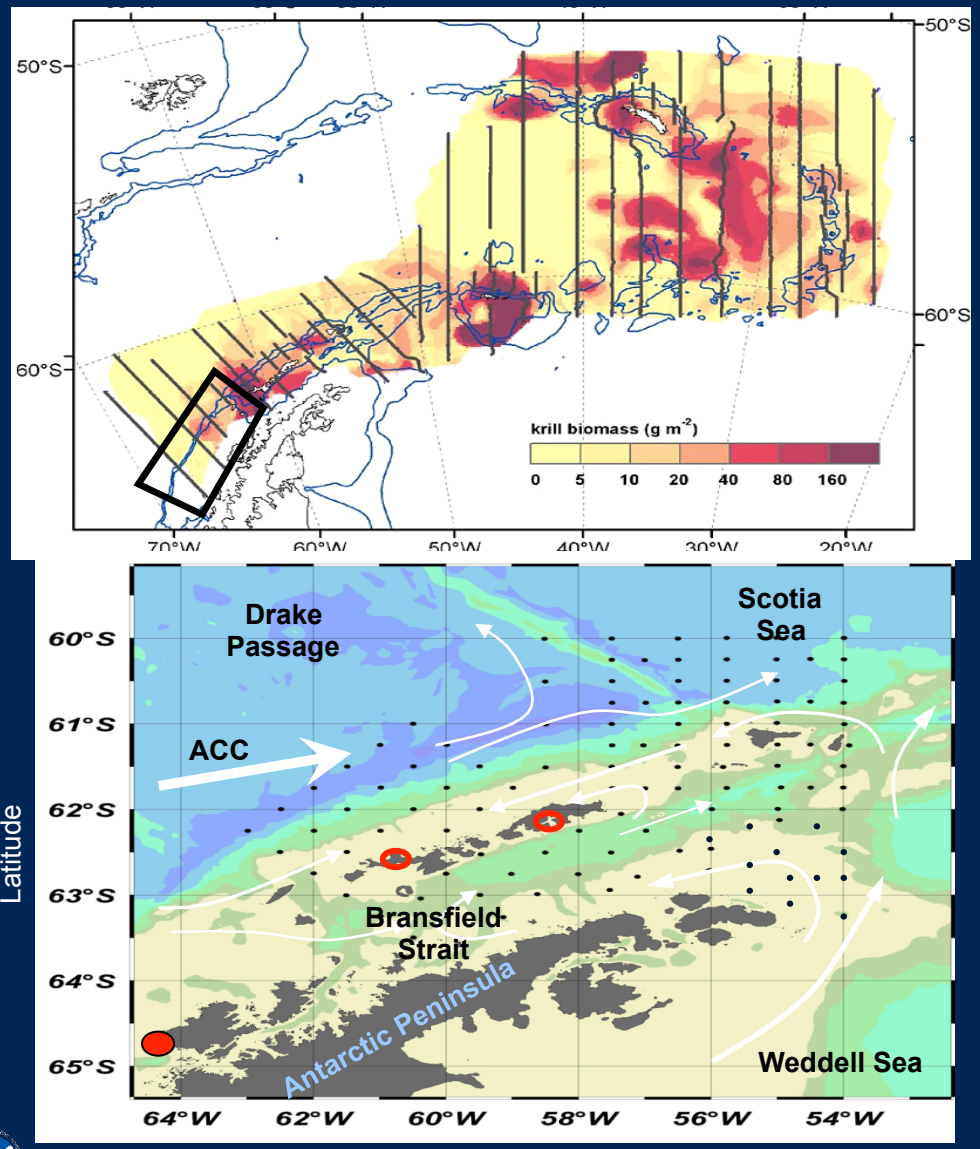
Acoustic krill Biomass (g m^{-2})



Local catch limits based on large-scale patterns not appropriate because fishing effort is locally concentrated. Need data at appropriate spatial and temporal scales to test concepts and advance FBM in CCAMLR

From 1990 to 2011 mostly two surveys per summer (mid-Jan. and mid-Feb.); each survey includes acoustics and nets

Since 2012 (4 years so far) switched to winter (August – September)

Acoustic estimation of krill biomass using CCAMLR approved approach

Oceanographic data collected for context and climate studies

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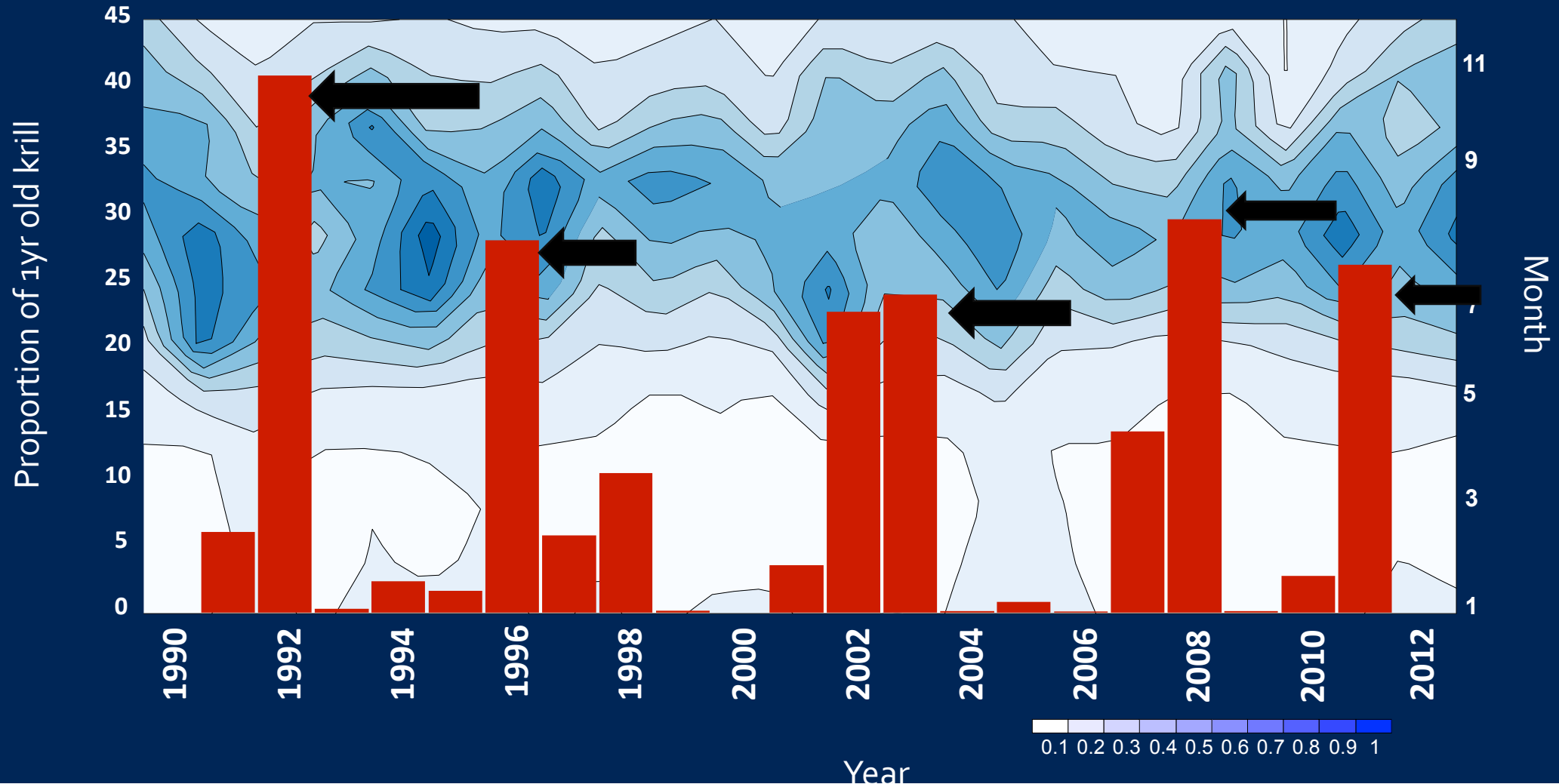
Principal finding from studies in Southern Ocean is that krill production and recruitment tied to seasonal sea-ice dynamics and climate variability



NOAA FISHERIES

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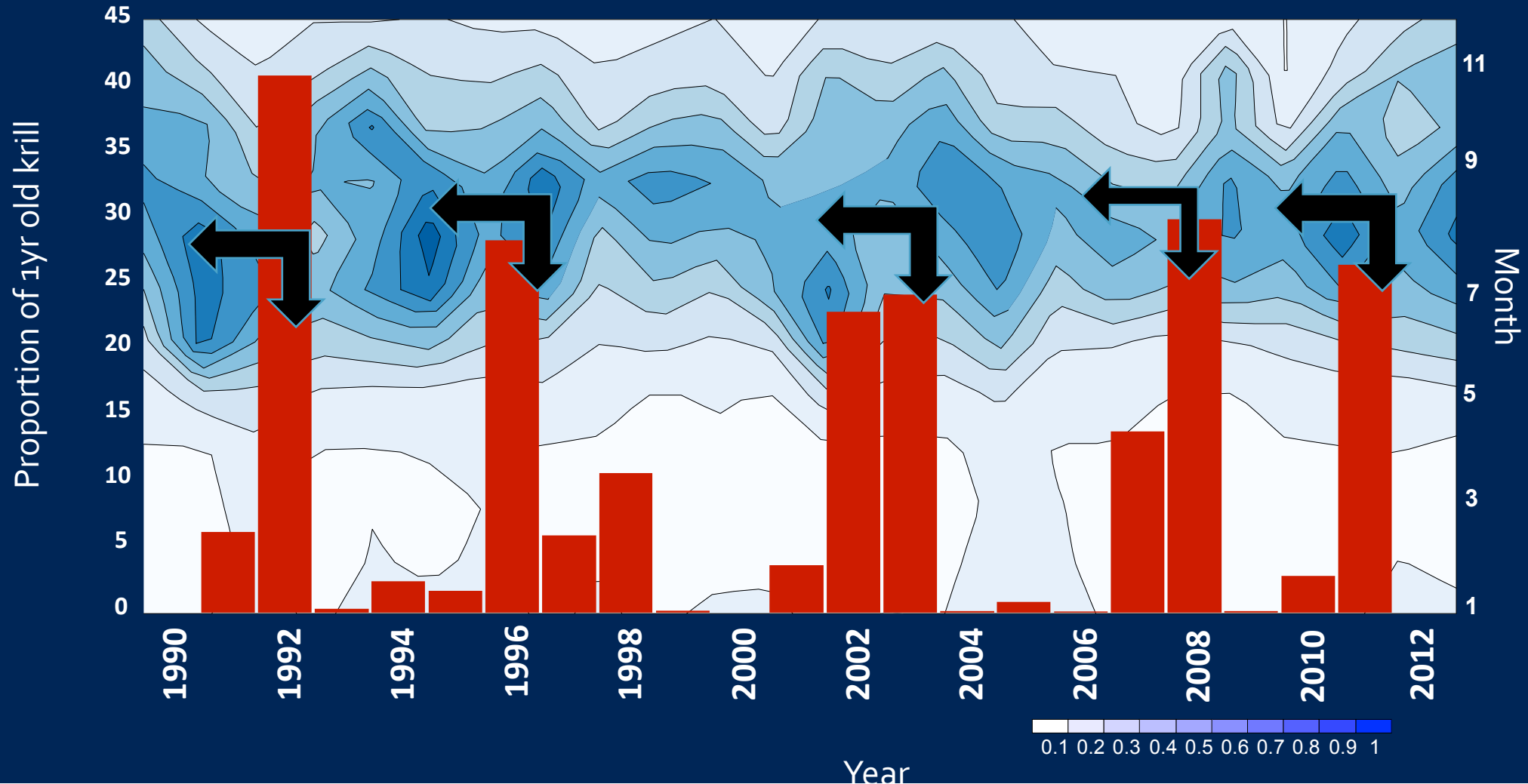

NOAA FISHERIES

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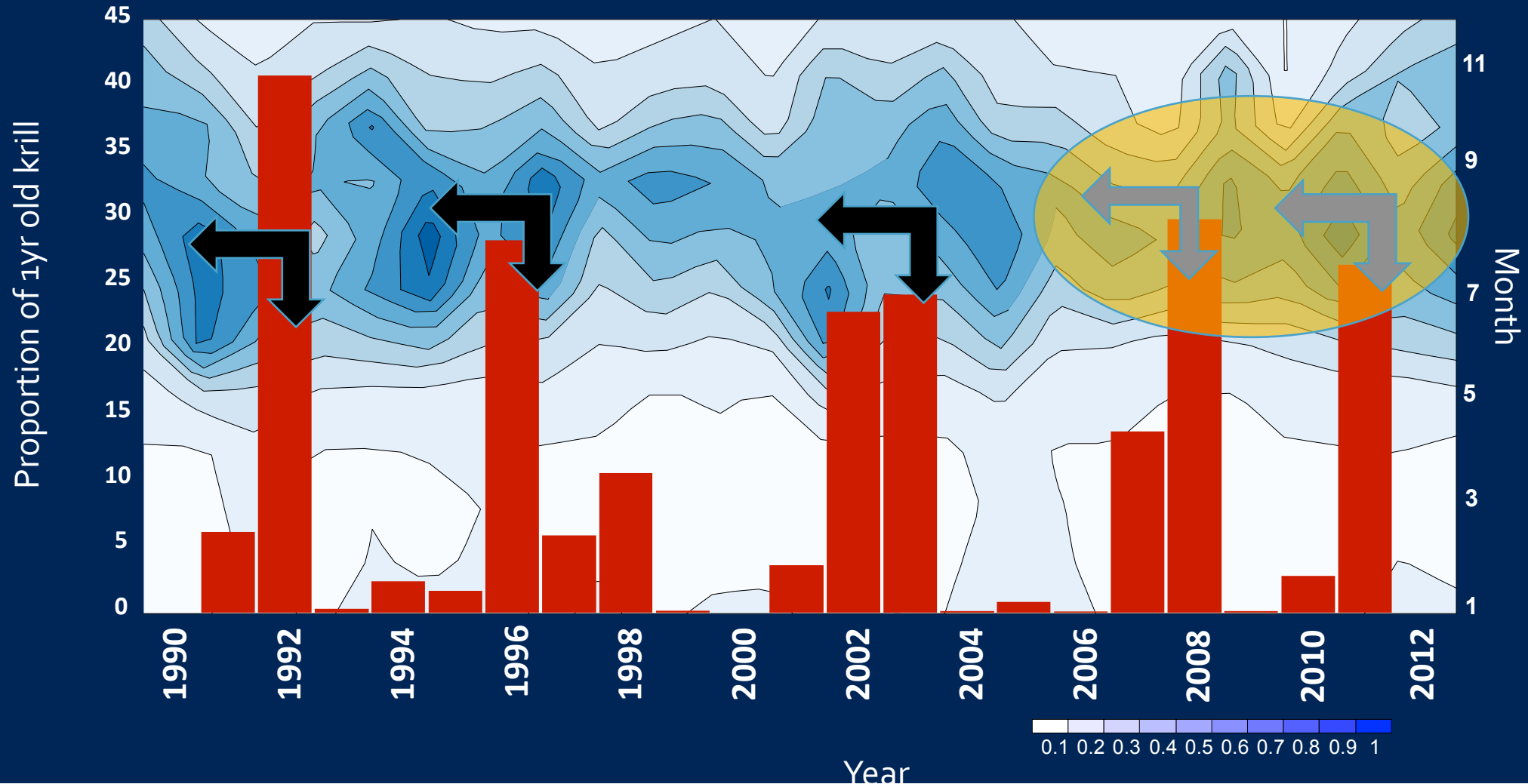

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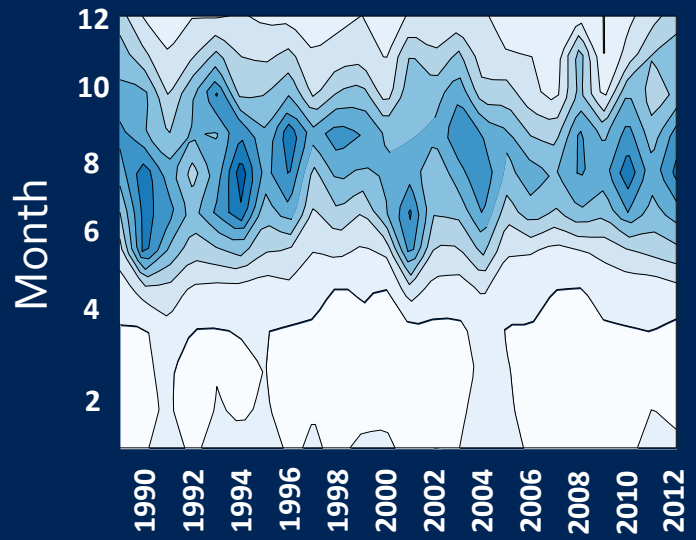
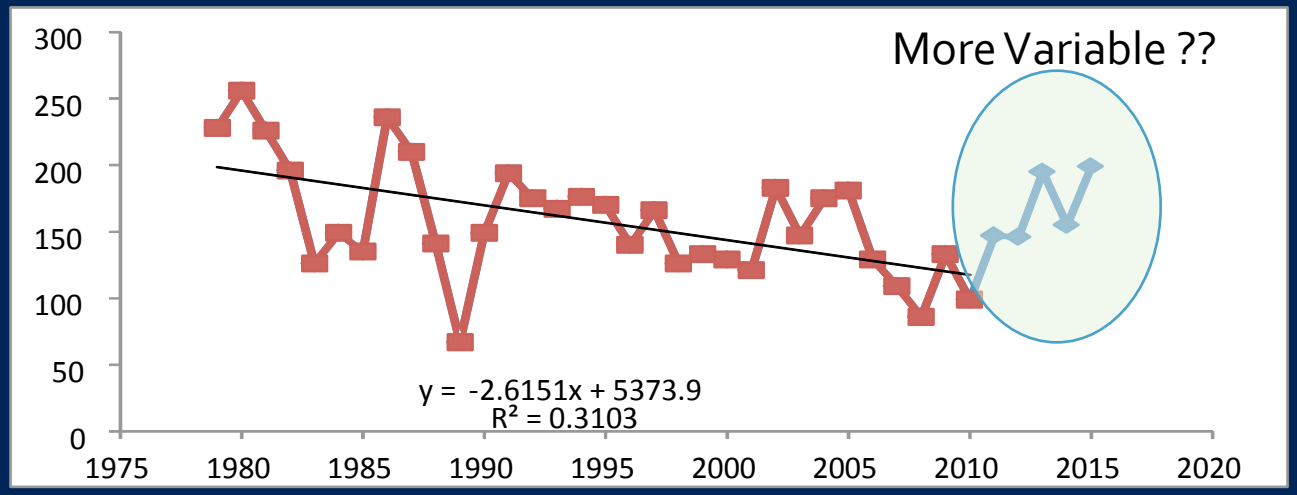
Declines in sea-ice extent and duration increase access to previously unfished areas





Later sea-ice advance (56 days) and earlier retreat (31 days) between 1980 and 2010

Imagine:

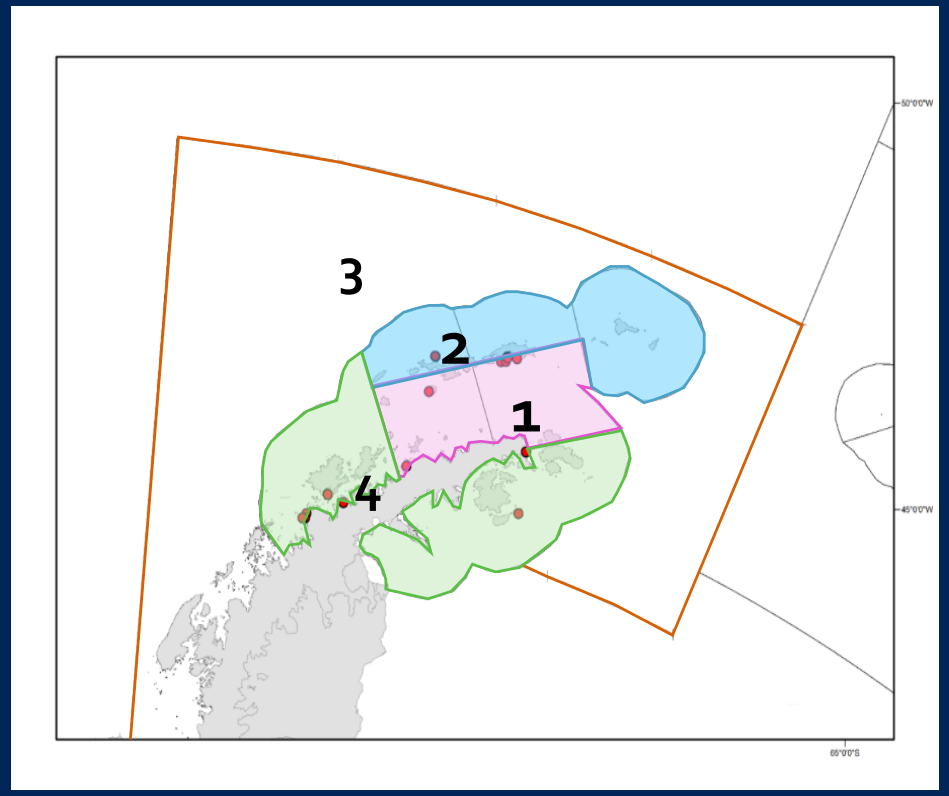
60 day delay in upwelling

Fishing expanded to times and areas previously ice covered

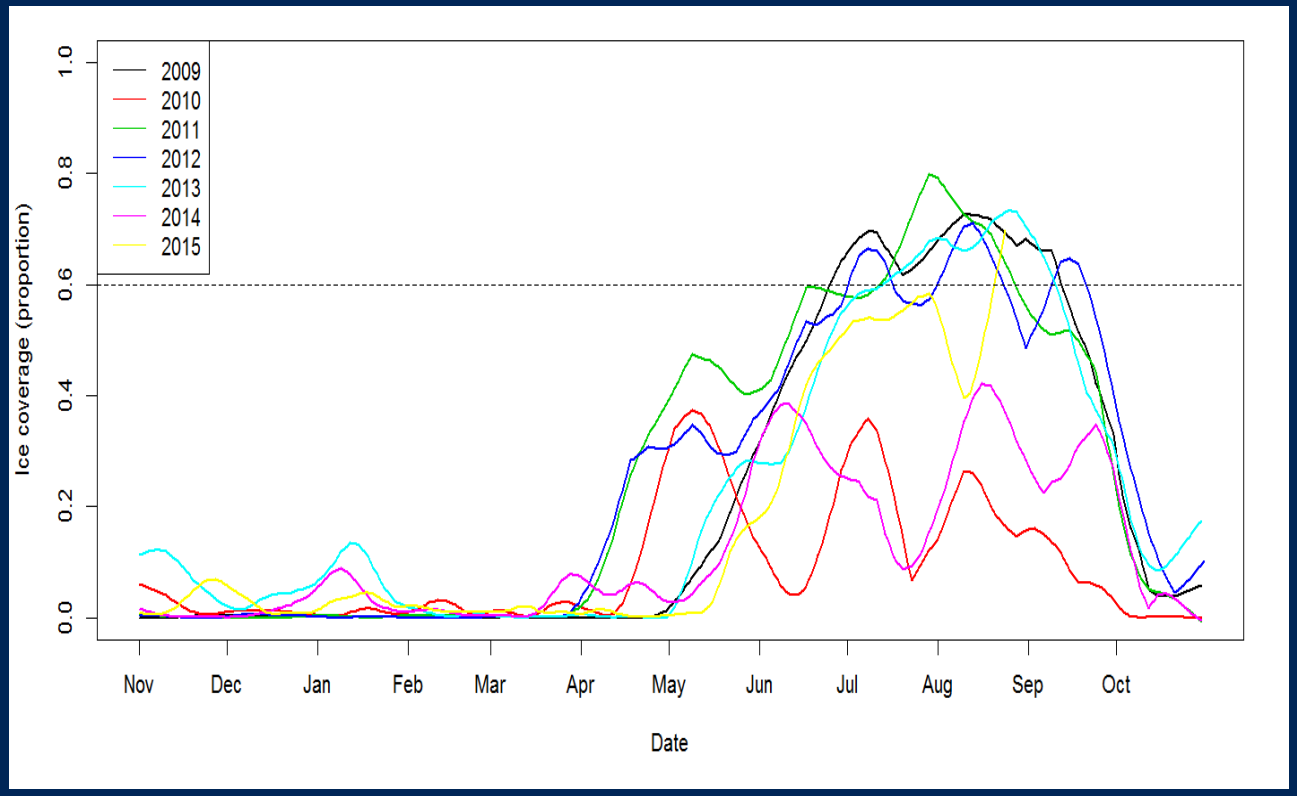
Increase competition with species outside current monitoring periods

Changes dynamics of seasonal cycles and coupling between different trophic levels

Inter-annual variability in sea ice impacts accessibility to local fishing areas



Bransfield Strait



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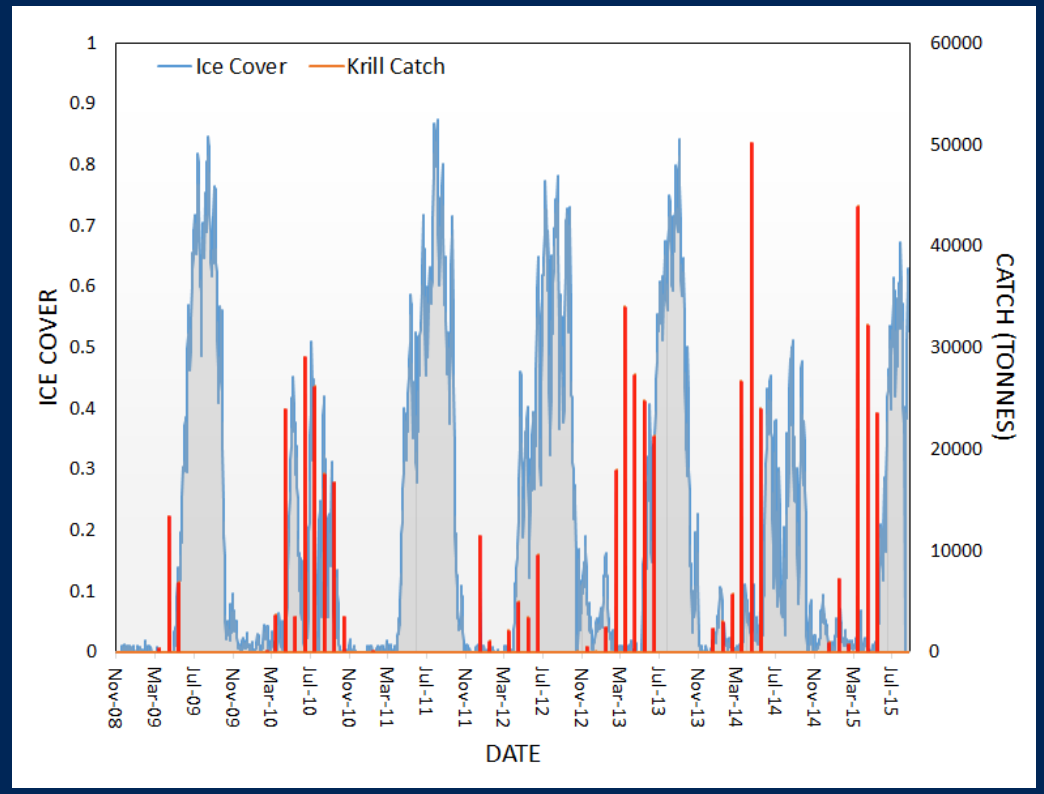
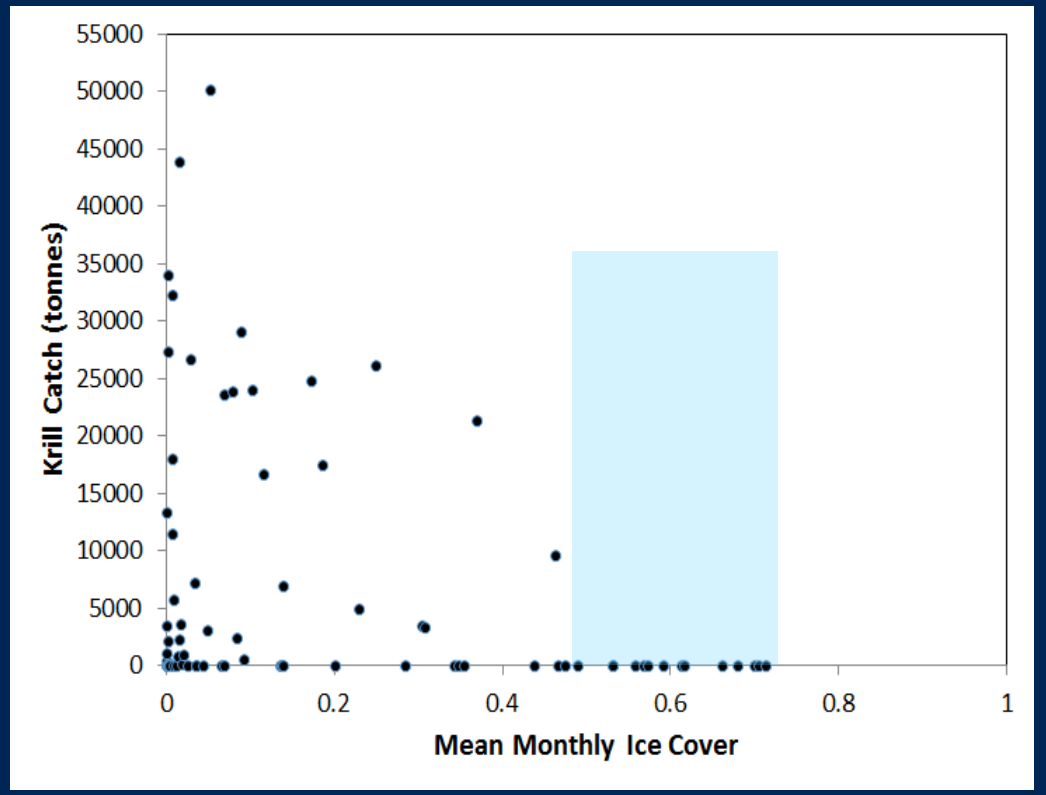
Krill catch declines when ice concentration exceeds 50% in Bransfield Strait





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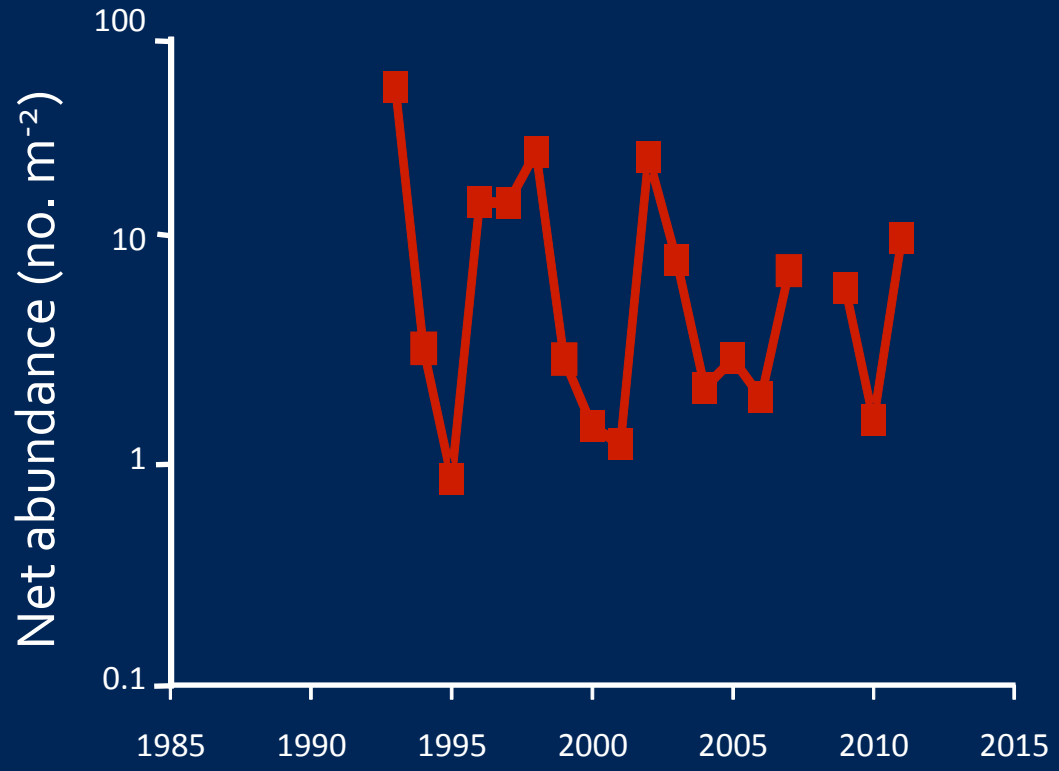
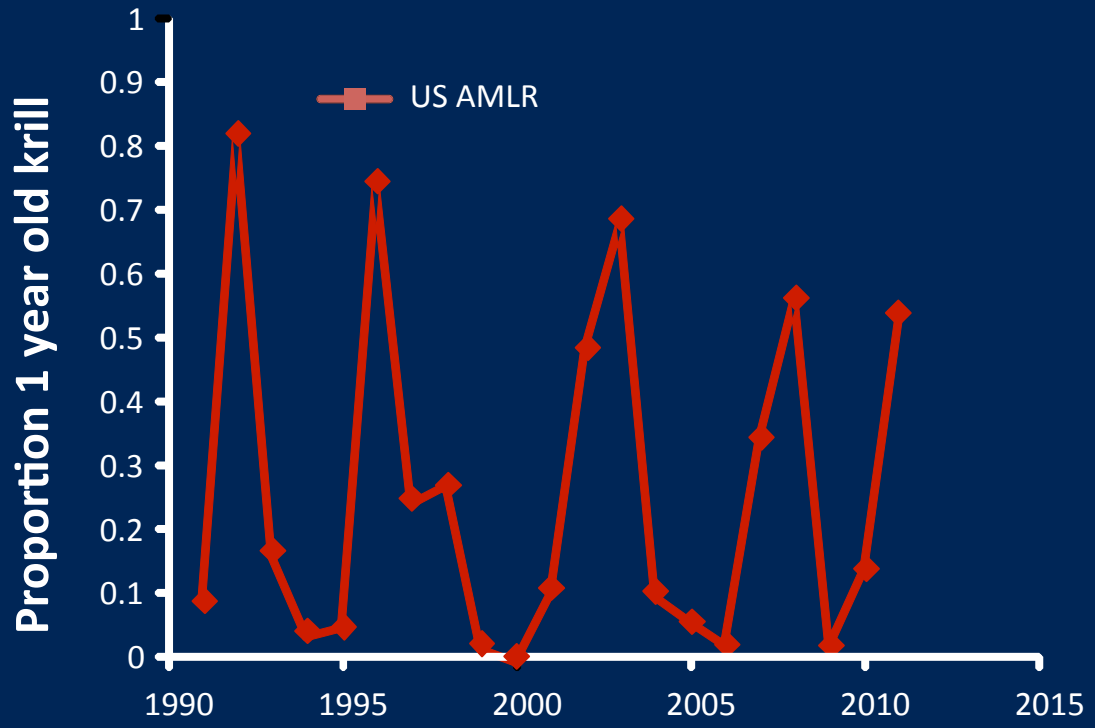
Krill abundance varies significantly between years



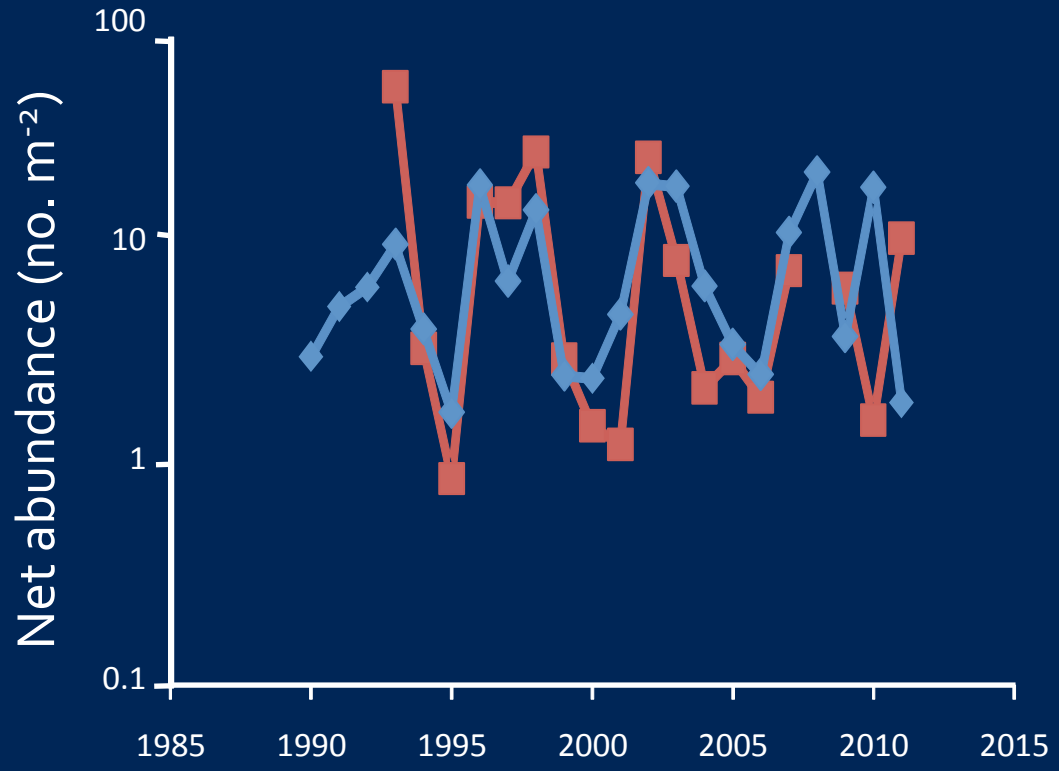


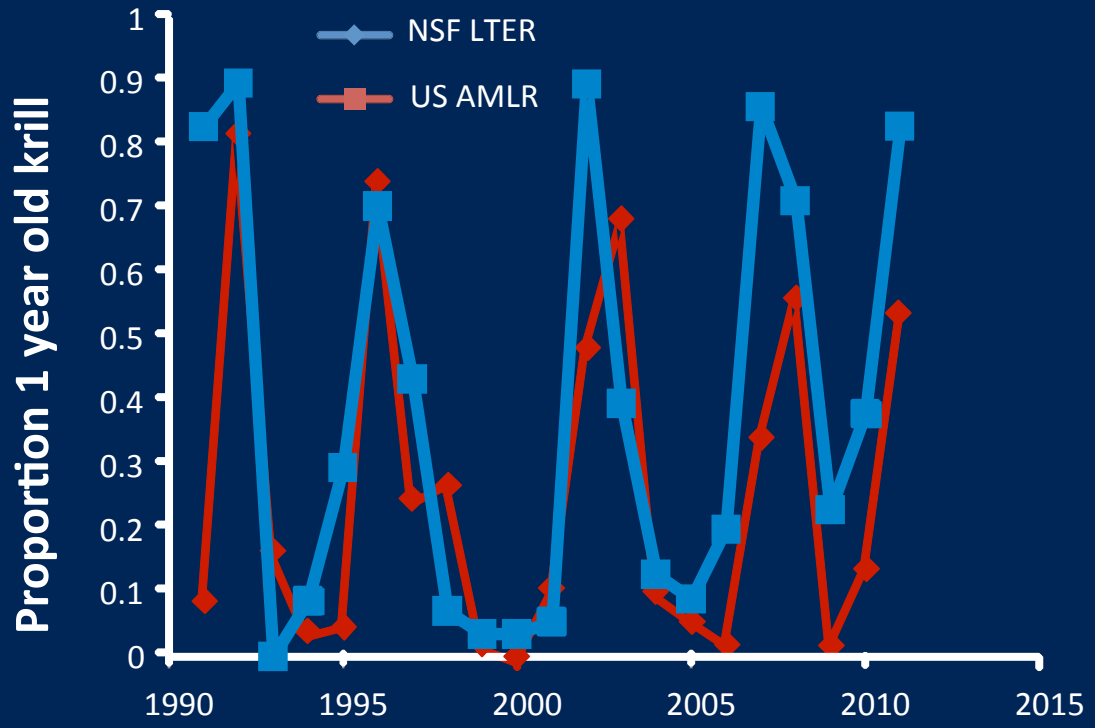
Year

NOAA FISHERIES

Reiss 2016

High correlation along the peninsula indicates a single fluctuating population



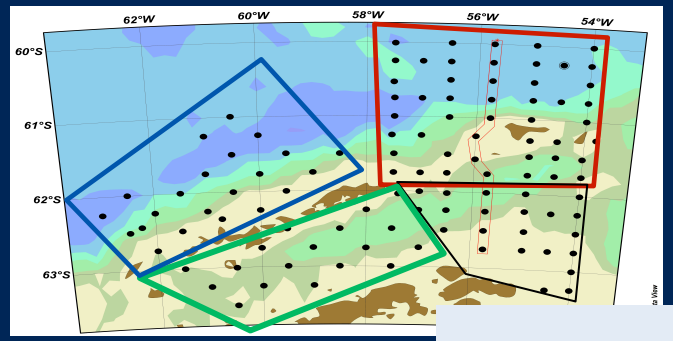


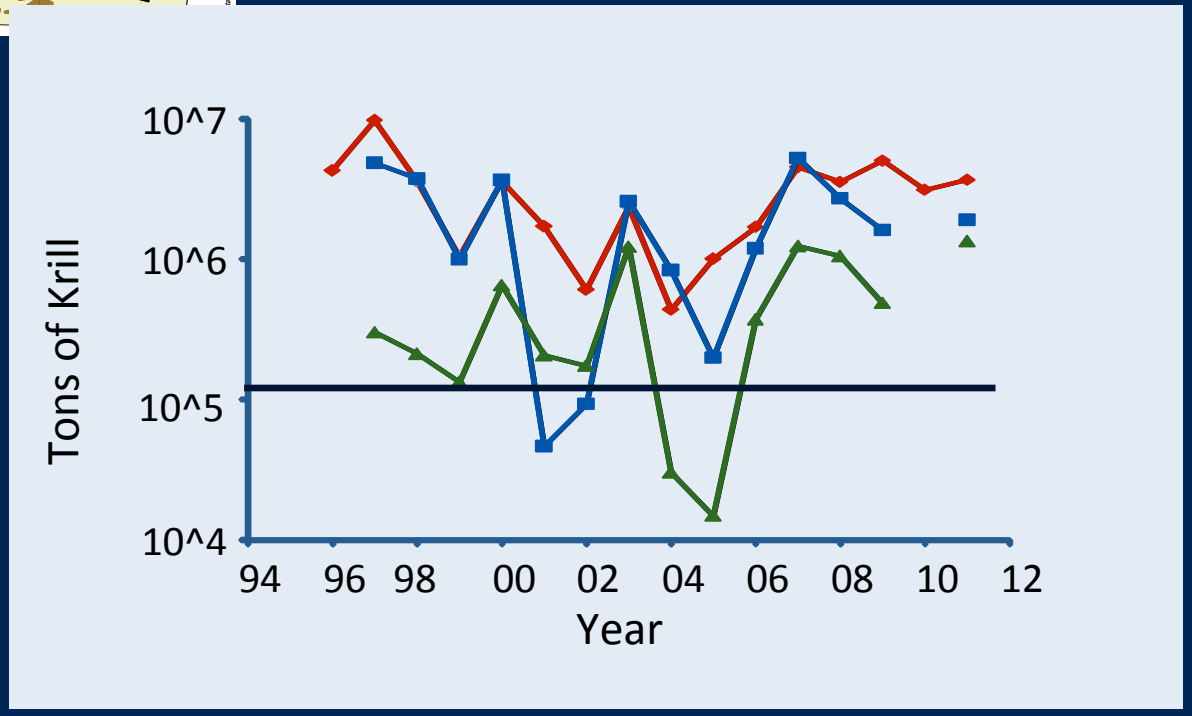
Year

NOAA FISHERIES

Reiss 2016

Focusing at a smaller scale a similar spatially cohesive pattern emerges





No temporal trend

Significant temporal variability (> 1 order of magnitude)

Spatial variability in biomass can exceed two orders of magnitude

Correlation between local areas is fairly high in most years

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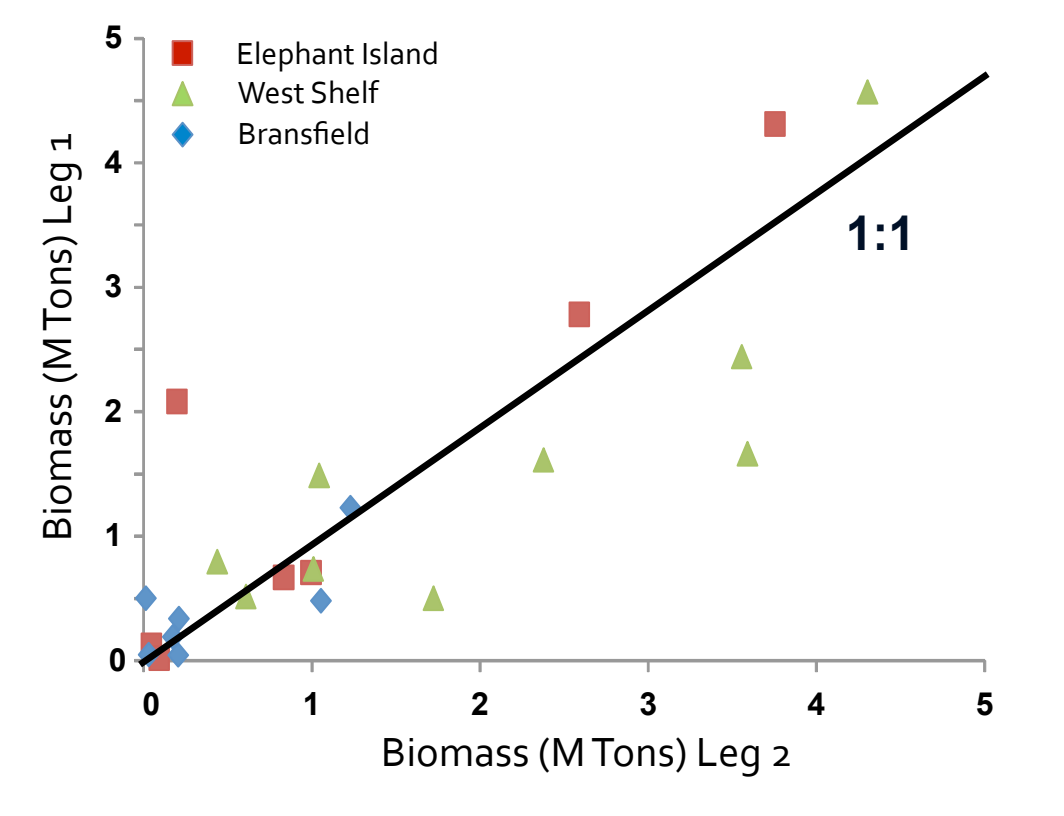
The ratio of biomass between summer surveys shows declines in most years in most local areas



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The spatio-temporal variability and correlation between areas and surveys has important consequences for the flux argument

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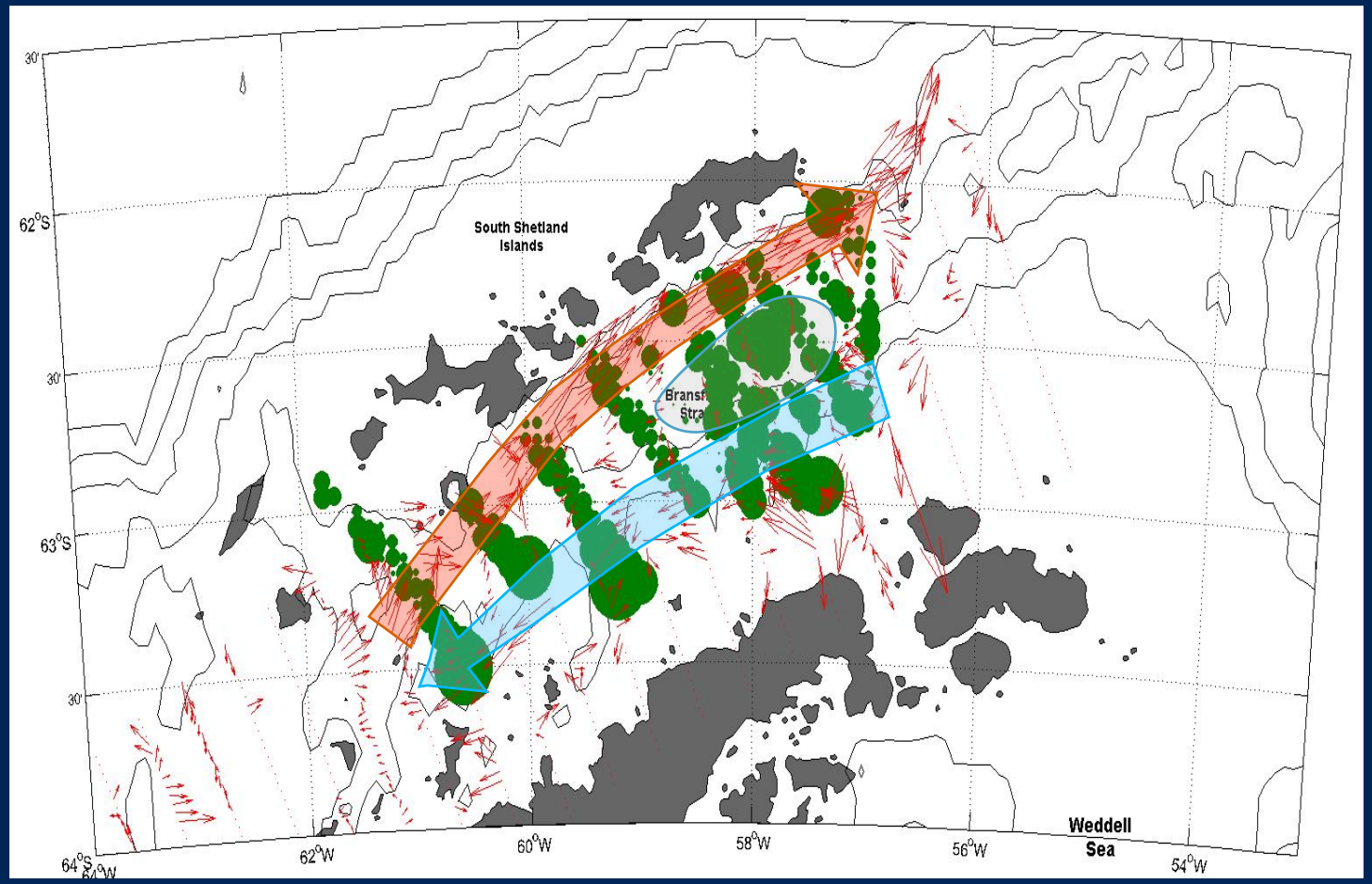
Distribution of krill in relation to observed current structure identifies potential links



Highest concentrations of krill are associated with bathymetric features and changing current patterns

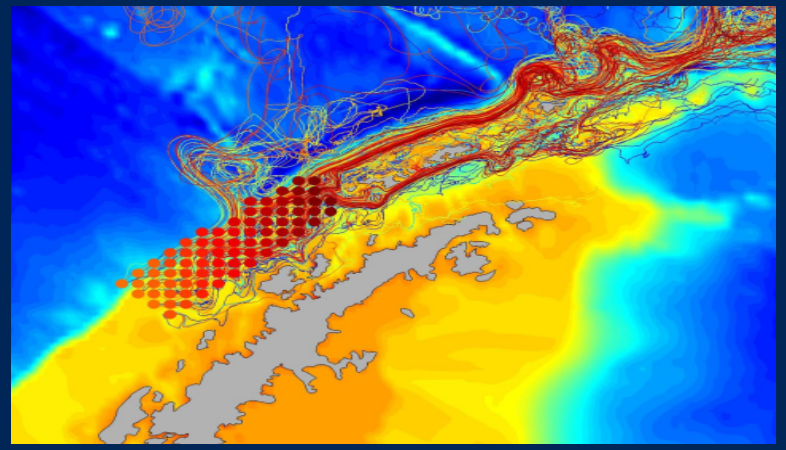
Such aggregations argue for local areas of retention and accumulation rather than flux

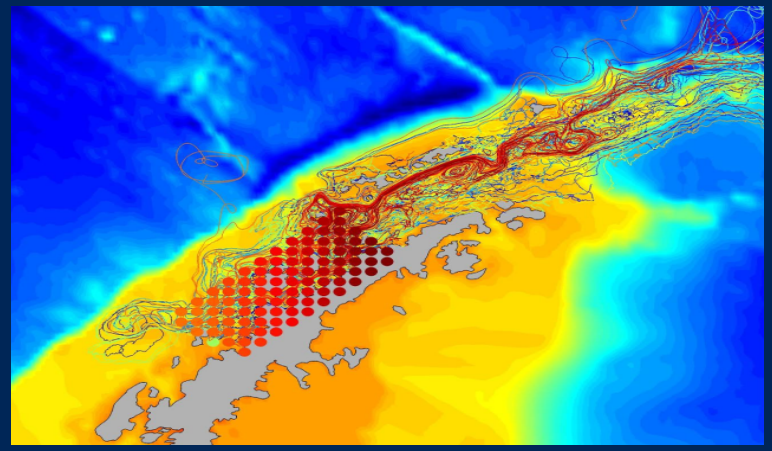
Thus, fishing on aggregations may result in local depletion if replenishment rate is less than removal rate

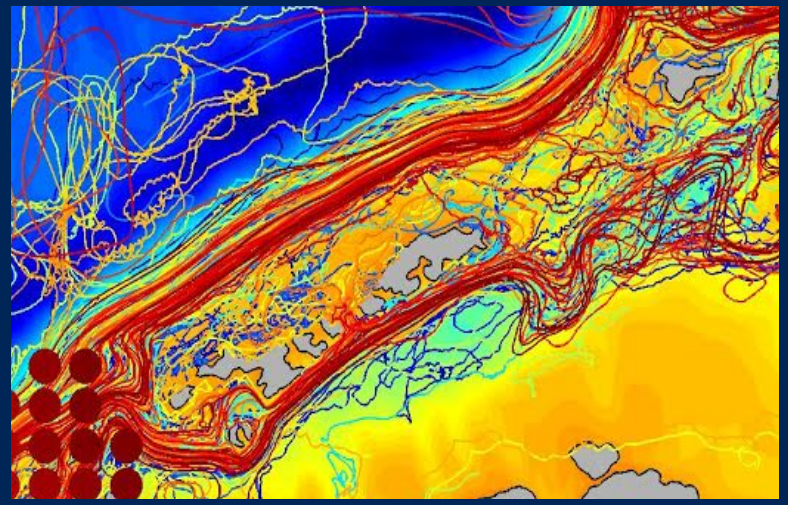
Reiss and Savidge (unpublished)

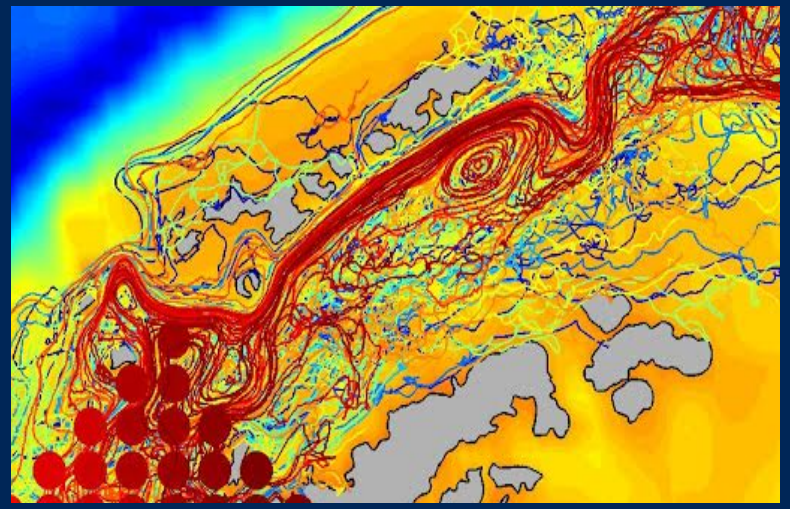
NOAA FISHERIES

Circulation modeling to identify areas of advection and retention









Jiang and Reiss (unpublished)

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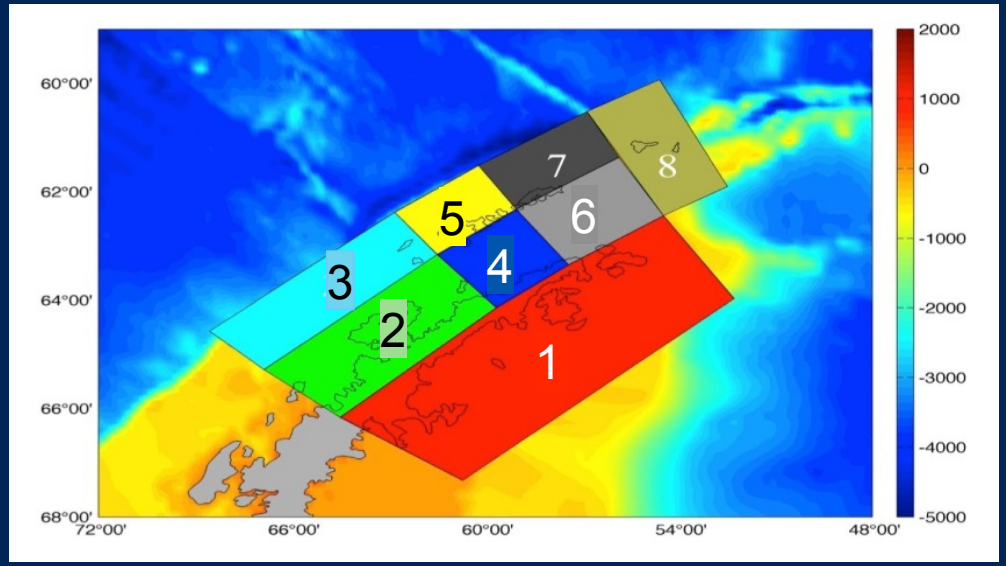
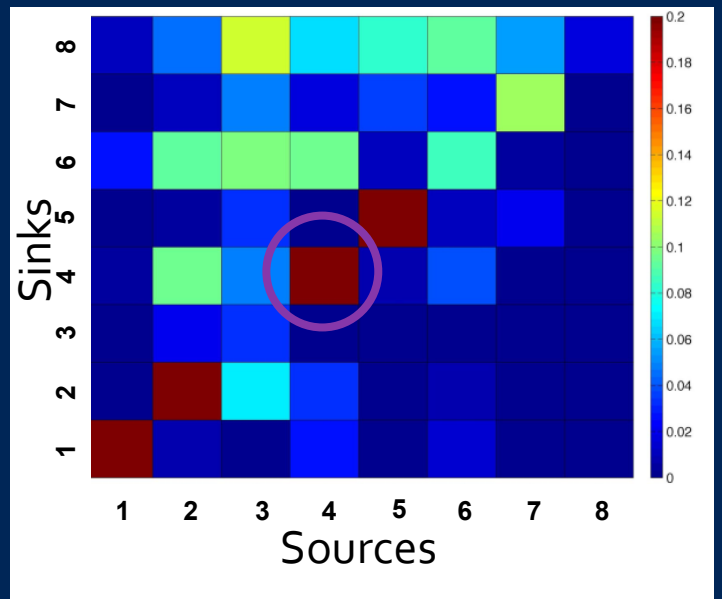
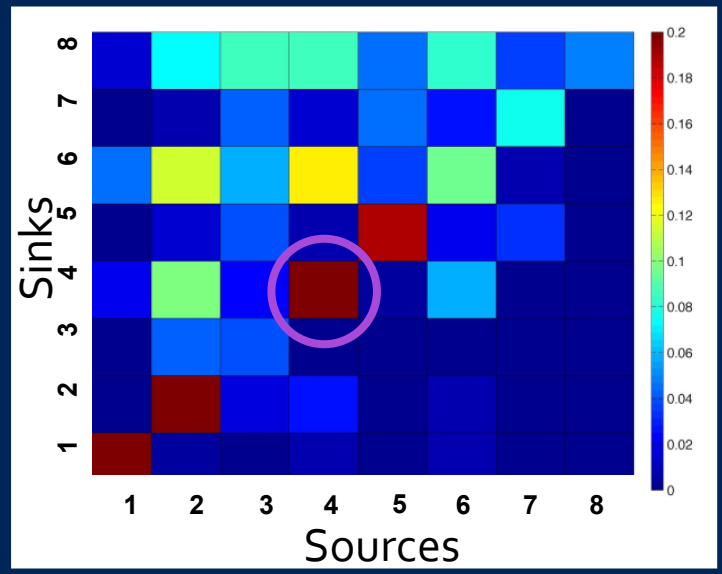
High levels of retention within coastal areas in both summer and winter



Summer



Winter



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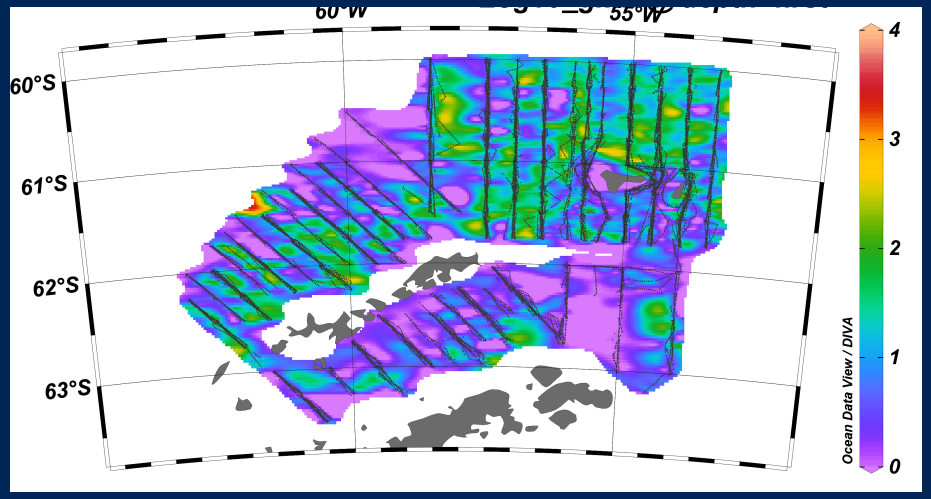
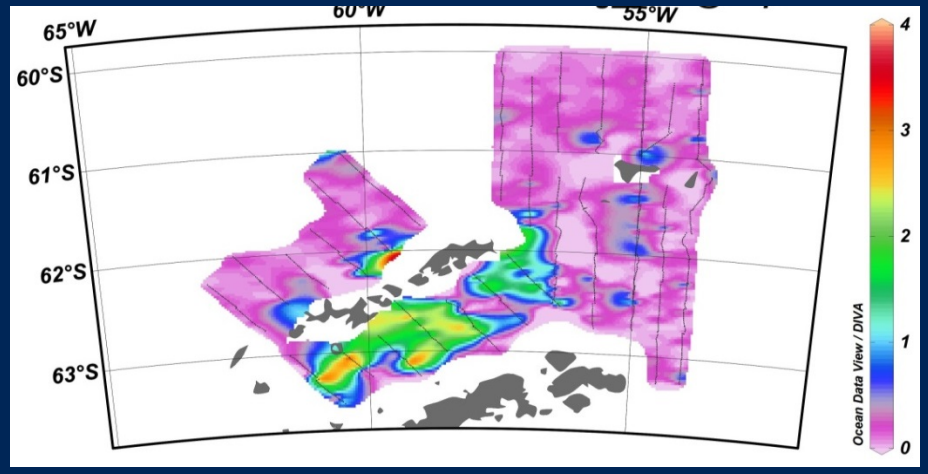
Seasonal differences in distribution of biomass indicates seasonal change in behavior

Summer average distribution of biomass



Winter distribution of biomass



- Seasonal migration between on-shore and off-shore habitats
- Seasonal concentration in southern areas

Reiss et al. In Review

NOAA FISHERIES

The Perfect Storm

Sea ice variability – krill more available in autumn and winter and what about krill production?

Advection and retention – fishing seems focused in areas of retention and what are local replenishment rates?

Seasonality – krill more concentrated in autumn and winter and what about potential competition between predators and the fishery at this time?

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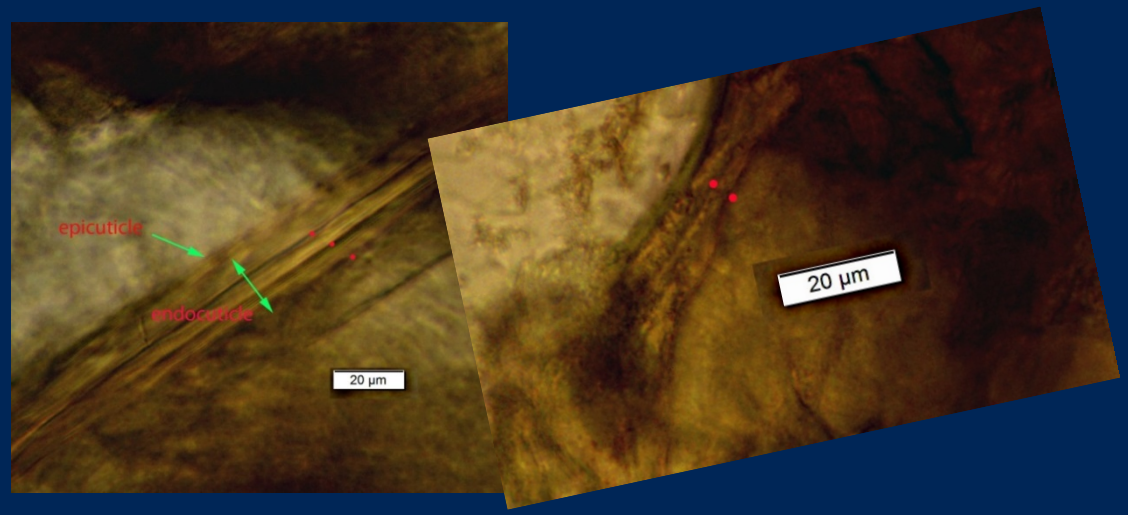
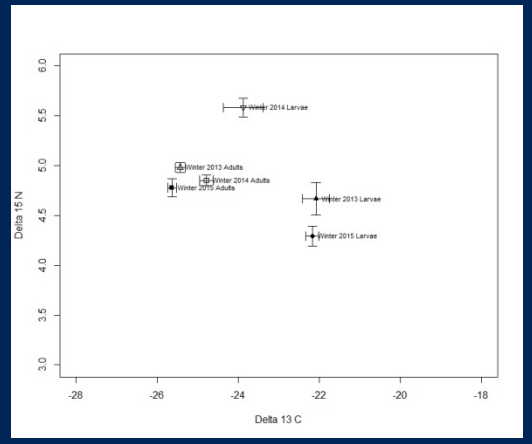
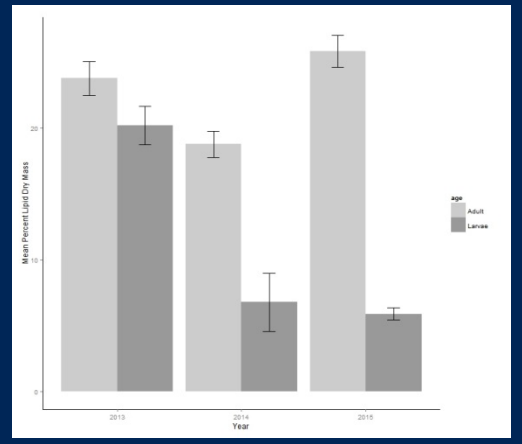
Cool stuff we are doing but didn't tell you about

- Development of a direct ageing technique for krill
- Over winter studies of krill and other plankton
- At-sea studies of spatial ecology of birds and mammals
- Comparative studies of krill ecology and recruitment in Southern Ocean
- Acoustic characterization of krill habitat use and comparison to Bering Sea

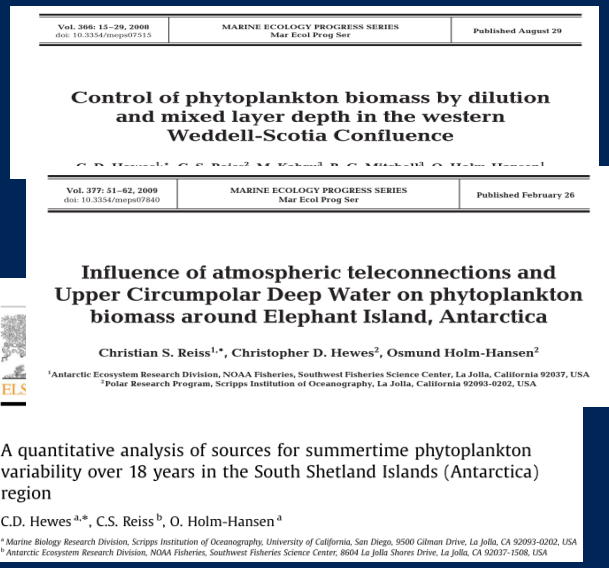






NOAA FISHERIES

Large number of papers using the time series of data collected between 1990 and 2011 to understand climate and ecosystem relationships



Control of phytoplankton biomass by dilution and mixed layer depth in the western Weddell-Scotia Confluence

Influence of atmospheric teleconnections and Upper Circumpolar Deep Water on phytoplankton biomass around Elephant Island, Antarctica

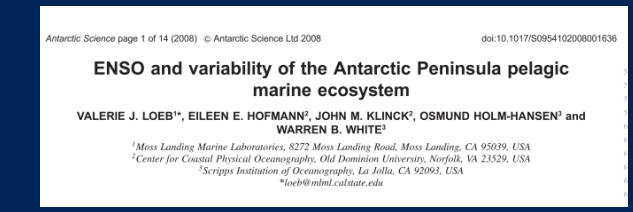
Christian S. Reiss[1,*], Christopher D. Hewes[2], Osmund Holm-Hansen[2]

[1]Antarctic Ecosystem Research Division, NOAA Fisheries, Southwest Fisheries Science Center, La Jolla, California 92037, USA
[2]Polar Research Program, Scripps Institution of Oceanography, La Jolla, California 92093-0202, USA

A quantitative analysis of sources for summertime phytoplankton variability over 18 years in the South Shetland Islands (Antarctica) region

C.D. Hewes[a,*], C.S. Reiss[b], O. Holm-Hansen[a]

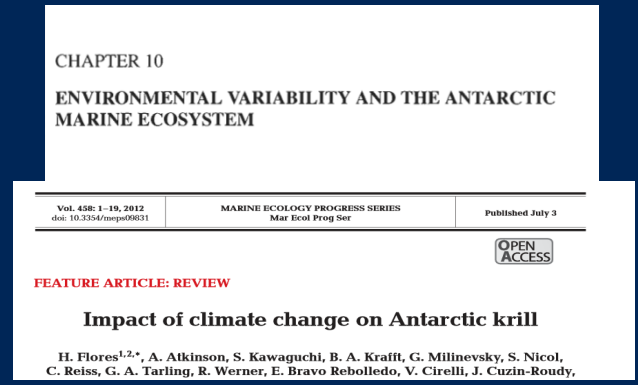
[a] Marine Biology Research Division, Scripps Institution of Oceanography, University of California, San Diego, 9500 Gilman Drive, La Jolla, CA 92093-0202, USA
[b] Antarctic Ecosystem Research Division, NOAA Fisheries, Southwest Fisheries Science Center, 8604 La Jolla Shores Drive, La Jolla, CA 92037-1508, USA



ENSO and variability of the Antarctic Peninsula pelagic marine ecosystem

VALERIE J. LOEB[1*], EILEEN E. HOFMANN[2], JOHN M. KLINCK[2], OSMUND HOLM-HANSEN[3] and WARREN B. WHITE[3]

[1]Moss Landing Marine Laboratories, 8272 Moss Landing Road, Moss Landing, CA 95039, USA
[2]Center for Coastal Physical Oceanography, Old Dominion University, Norfolk, VA 23529, USA
[3]Scripps Institution of Oceanography, La Jolla, CA 92093, USA
*loeb@mlml.calstate.edu



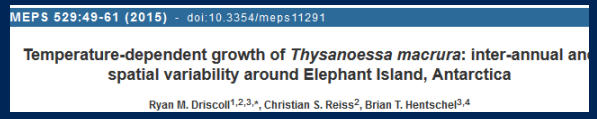
CHAPTER 10

ENVIRONMENTAL VARIABILITY AND THE ANTARCTIC MARINE ECOSYSTEM

FEATURE ARTICLE: REVIEW

Impact of climate change on Antarctic krill

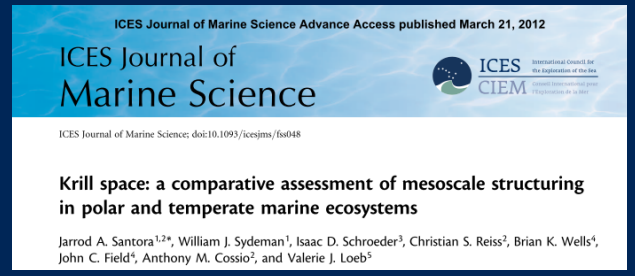
H. Flores[1,2,*], A. Atkinson, S. Kawaguchi, B. A. Krafft, G. Milinevsky, S. Nicol, C. Reiss, G. A. Tarling, R. Werner, E. Bravo Rebolledo, V. Cirelli, J. Cuzin-Roudy,



MEPS 529:49-61 (2015) - doi:10.3354/meps11291

Temperature-dependent growth of *Thysanoessa macrura*: inter-annual and spatial variability around Elephant Island, Antarctica

Ryan M. Driscoll[1,2,3,*], Christian S. Reiss[2], Brian T. Hentschel[3,4]



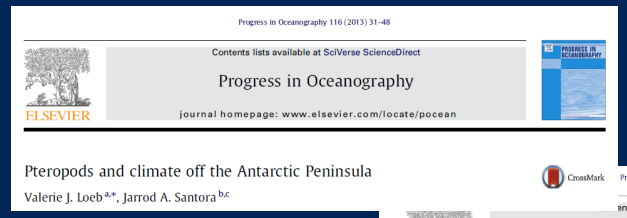
ICES Journal of Marine Science Advance Access published March 21, 2012

ICES Journal of Marine Science

ICES Journal of Marine Science; doi:10.1093/icesjms/fss048

Krill space: a comparative assessment of mesoscale structuring in polar and temperate marine ecosystems

Jarrod A. Santora[1,2*], William J. Sydeman[1], Isaac D. Schroeder[3], Christian S. Reiss[2], Brian K. Wells[4], John C. Field[4], Anthony M. Cossio[2], and Valerie J. Loeb[5]



Progress in Oceanography 116 (2013) 31–48

Contents lists available at SciVerse ScienceDirect

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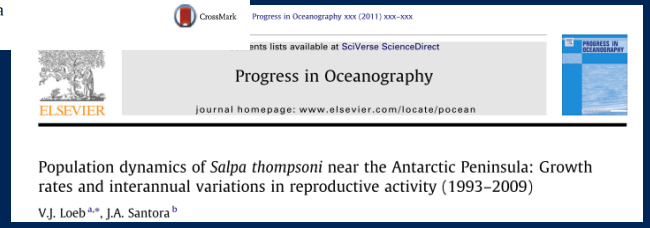
journal homepage: www.elsevier.com/locate/pocean

Pteropods and climate off the Antarctic Peninsula

Valerie J. Loeb[a,*], Jarrod A. Santora[b,c]



Progress in Oceanography xxx (2011) xxx–xxx

Contents lists available at SciVerse ScienceDirect

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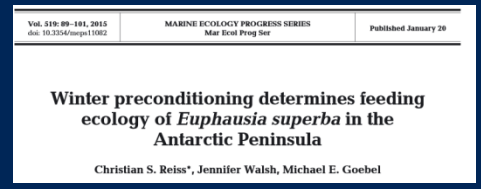
journal homepage: www.elsevier.com/locate/pocean

Population dynamics of *Salpa thompsoni* near the Antarctic Peninsula: Growth rates and interannual variations in reproductive activity (1993–2009)

V.J. Loeb[a,*], J.A. Santora[b]



Winter preconditioning determines feeding ecology of *Euphausia superba* in the Antarctic Peninsula

Christian S. Reiss*, Jennifer Walsh, Michael E. Goebel

Growth and shrinkage in Antarctic krill (*Euphausia superba* Dana) is sex-dependent

G. A. Tarling, S. Hill, H. Peat, S. Fielding, C. Reiss, A. Atkinson

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Answers to TOR questions

4. What is the status of oceanographic, habitat, climate, and ecological data required to fulfill ecosystem-related science needs?

The U.S. AMLR Program collects a large amount of oceanographic and acoustic data. Additional data streams (satellite and re-analysis products) are used and numerical modeling could be useful.

5. Are we appropriately analyzing and modeling ecosystem-level processes?

Data have been provided to global programs (CCAMLR; SONA; SEABASS; SOSE; KRILLBASE; GDP) to further analyses and broaden collaborations.

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STRENGTHS

- Long time series is unique in Antarctic
- Enjoy high level of goodwill with other scientists – for now

STRATEGIES

- Expand collaborations with other nations
- Use fishing vessels to collect data for management decisions

CHALLENGES

- Maintenance of time series is problematic
- Reliance on foreign nations for key ship-based work
- Long-term commitment by fishing companies is uncertain

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